

RTCA Special Committee 209
Mode S Transponder MOPS Maintenance
Working Group #1, Meeting #6

Engility Corporation, Washington DC
14 – 16 April 2008

Clarification of the Side Lobe Suppression Issue by
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With Commentary from Bob Saffell

SUMMARY

This Working Paper tries to clarify the modifications regarding the 1% and 10% reply rates. It was originated by Antoine Herve and commented on by Bob Saffell.

SLS Side Lobe suppression :

Working Paper to clarify the modifications regarding the 1% and 10% reply rate.

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| <p>ED 73C</p> <p>3.8.2 Side Lobe Suppression, Mode A/C, Mode A/C-Only All-Call, and Mode A/C/S All-Call</p> <p>Assuming no lock-out condition is in effect, the transponder shall react to side lobe interrogations as follows.</p> <p>a. Conditions Under Which the Transponder SHALL Be Suppressed</p> <p>The transponder shall reply to no more than 10% of the interrogations if</p> <ol style="list-style-type: none"> (1) the pulse interval between P1 and P2 is varied over the range from 1.85 to 2.15 μs, and (2) the RF input signal level of P1 is varied from MTL+3dB to -21 dBm, and (3) the level of P2 equals or exceeds the level of P1. <p>NOTE: <i>The transponder will enter suppression if the P1 and P2 preamble pulses of a Mode S interrogation are detected, but a sync phase reversal is not recognised. This requirement prevents the transponder from generating unwanted Mode A and/or Mode C replies to Mode S interrogations that are sidelobe suppressed.</i></p> | <p>DO 181</p> <p>2.2.5.1 Side Lobe Suppression, ATCRBS, ATCRBS-Only All-Call, and ATCRBS/Mode S All-Call</p> <p>The transponder shall react to side lobe interrogations as follows:</p> <p>a. Conditions Under Which the Transponder SHALL Be Suppressed</p> <p>The transponder shall reply to no more than one percent of the interrogations</p> <p>under all combinations of the following conditions:</p> <ol style="list-style-type: none"> (1) when the pulse interval between P1 and P2 is varied over the range from 1.85 to 2.15 microseconds, (2) when the RF input signal level of P1 is varied from 3 dB above MTL to -21 dBm, (3) when the level of P2 equals or exceeds the level of P1. | <p><u>Change in ED 73C 10% by 1%</u></p> <p><u>RHS Commentary:</u></p> <p>The 1% requirement comes from the U.S. Code of Federal Regulations, Chapter 14, Part 43, Appendix F, section (b)(1). This document is attached with the requirement highlighted in yellow and blue for your convenience.</p> <p>When it is required that a P1-P2 pulse sequence MUST BE ACCEPTED as in this case, the intent is for the transponder to NOT REPLY at all. Therefore the requirement is set at 1%.</p> <p>Also, ICAO Annex 10, Volume IV, July 2007, provides 3.1.1.7.4 SUPPRESSION</p> <p><i>Note.— This characteristic is used to prevent replies to interrogations received via the side lobes of the interrogator antenna, and to prevent Mode A/C transponders from replying to Mode S interrogations.</i></p> <p>3.1.1.7.4.1 The transponder shall be suppressed when the received amplitude of P_2 is equal to, or in excess of, the received amplitude of P_1 and spaced 2.0 plus or minus 0.15 microseconds. The detection of P_3 is not required as a prerequisite for initiation of suppression action.</p> <p>3.1.1.7.4.2 The transponder suppression shall be for a period of 35 plus or minus 10 microseconds.</p> <p>3.1.1.7.4.2.1 The suppression shall be capable of being reinitiated for the full duration within 2 microseconds after the end of any suppression period.</p> <p>Last but not least, DO-181D section 2.2.5.1.a sets the requirement at one percent.</p> <p>So, my recommendation is to make it “one percent”.</p> |
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| <p>b. Conditions Under Which the Transponder SHALL NOT Be Suppressed</p> <p>The transponder shall reply to at least 90% of the interrogations over the input signal level range of from MTL+3dB to -21 dBm, if</p> <ol style="list-style-type: none"> (1) the level of P1 exceeds the level of P2 by 9 dB or more, or (2) no pulse is received at the position 2.0 ±0.7 µs, following P1, or (3) the duration of P2 is less than 0.3 µs. | <p>b. Conditions Under Which the Transponder SHALL NOT Be Suppressed</p> <p>The transponder shall reply to at least 90 percent of the interrogations over the input signal level range of 3 dB above MTL to -21 dBm, when:</p> <ol style="list-style-type: none"> (1) (I) the level of P1 exceeds the level of P2 by 9 dB or more, (2) no pulse is received at the position 2.0 ±0.7 microseconds following P1, (3) the duration of P2 is less than 0.3 microsecond. | <p>OK harmonized</p> |
| <p>c. Conditions Under Which The Transponder SHALL NOT Reply, But May Initiate Suppression.</p> <ol style="list-style-type: none"> (1) The transponder shall not reply with more than a 10% reply rate over the RF input level range from MTL to MTL+3dB, if the amplitude of P2 equals or is greater than the amplitude of P1. (2) Under the same conditions, the transponder may or may not initiate suppression. | <p>c. Conditions Under Which Transponder SHALL NOT Reply but May Initiate Suppression</p> <p>The transponder shall not reply with more than 10 percent reply ratio over the RF input level range from MTL to MTL +3 dB, if the amplitude of P2 equals or is greater than the amplitude of P1.</p> <p>Under the same conditions, the transponder may or may not initiate suppression.</p> | <p>OK harmonized</p> |
| <p>ED 73</p> <p>5.4.4 Side Lobe Suppression (Paragraph 3.8)</p> <p>5.4.4.1 Mode A/C, Mode A/C-only All-Call and Mode A/C/S All-Call</p> <p>5.4.4.1.1 Test Equipment</p> <ol style="list-style-type: none"> a. 2 Transponder Test Sets. b. Wide Band Dual Channel Oscilloscope. c. 3 Port Divider. <p>5.4.4.1.2 Test Procedure</p> <p>Connect the equipment as shown in Figure 5-5.</p> <ol style="list-style-type: none"> a. <u>STEP 1 - Suppression Duration</u> (Paragraph 3.8.1 a.) <p>Interrogate the transponder at 450 interrogations per second with a P1-P2 pulse pair followed, after 50 µs, by a P1-P3 (Mode A, 8 µs) pulse pair.</p> <p>NOTE: All pulse levels should be set to -24 dBm; any reply code may be selected.</p> | <p><u>DO 181</u></p> <p>2.4.2.4 Side Lobe Suppression (§2.2.5 and §2.2.8.5)</p> <p><u>Equipment Required:</u> ATC Test Set [T-50-3A/4A (2 required), or equivalent]. Wide Band Dual Channel Oscilloscope (HP 1710B, or equivalent). 3 Port Divider (Weinschel 1506, or equivalent). Measurement Procedure:</p> <p><u>Step 5 Suppression Duration [§2.2.5.1.d (I)]</u></p> <p>Interrogate the transponder at 450 interrogations per second with a P1 - P2 pulse pair, followed after 50 microseconds by a P1 - P3 (Mode A, 8 microseconds) pulse pair. The interrogation level shall be set at -24 dBm, reply code selection is not consequential. Reduce the spacing of the P1 - P3 pair with respect to the P1 - P2 pair until the transponder ceases to reply.</p> | <p>Not totally harmonized</p> <p>What does “cease to reply” exactly mean ? (fall under 10% or no answer at all ?)</p> <p><u>RHS Commentary:</u></p> <p>In this case, you are attempting to measure the duration of the Suppression Counter which should be between 25 and 45 microseconds. (See ICAO Volume IV, section 3.1.1.7.4.2 as shown in previous RHS_Commentary). As you are moving the P1-P3 pair into the P1-P2 pair, you want to do so until REPLIES STOP completely and determine the time between</p> |

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| <p>Reduce this 50 μs interval until the transponder reply rate falls below 10%.</p> <p>Measure the time interval between the leading edges of P2 and P1 (of the P1-P3 pair), and record this as the suppression duration S(8).</p> <p>Repeat the above procedure using Mode C (21-microsecond spacing) for the P1-P3 pair; record the result as suppression duration S(21).</p> | <p>The time interval between the leading edges of P2 and P1 (of the P1 - P3 pair) is the suppression duration S(8). Repeat above procedure using Mode C (21-microsecond spacing) for the P1 - P3 pair. The result will be suppression duration S(21).</p> | <p>the two interrogations.</p> <p>Therefore, the proper terminology for what you are attempting to do is “transponder ceases to reply”. That means NO More than ONE PERCENT REPLIES as per DO-181D section 2.2.5.1.a.</p> <p>It should be noted that ED-73C section 3.8.2 defines Suppression as less than 10 percent replies. DO-181D section 2.2.5.1.a defines suppression as less than 1 percent replies.</p> <p>ICAO Volume IV, section 3.1.1.7.2 uses the term “shall not reply”.</p> |
| <p>b. <u>STEP 2 - Suppression Re-initiation</u> (Paragraph 3.8.1 c.)</p> <p>With an interrogation rate of 450 interrogations per second, generate a first P1-P2 pair followed by a second P1-P2 pair such that the spacing between P2 of the first pair and P1 of the second pair is S(8) plus 2 μs.</p> <p>Generate a third pair, P1-P3 Mode A, 50 μs after the second pair.</p> <p>NOTE: All pulse levels should be set to -24 dBm; any reply code may be selected.</p> <p>Reducing the interval between the P1-P2 pair and the P1-P3 pair, record the interval at which the transponder replies fall below 10%.</p> <p>Repeat the test using Mode C spacing for the P1-P3 pair and determine suppression duration S(21).</p> <p>[Under environmental conditions, this procedure step is not required.]</p> | <p><u>Step 6 Suppression Reinitiation [§2.2.5.1.d (3)]</u></p> <p>Connect the equipment as shown in Figure 2-27. With an interrogation rate of 450 interrogations per second, generate a "first" P1 - P2 pair followed by a "second" P1 - P2 pair such that the spacing between P2 of the first pair and P1 of the second pair is S(8) +2 microseconds.</p> <p>Generate a "third" pair, P1 - P3, Mode A to follow the second pair after 50 microseconds.</p> <p>All pulse levels shall be set to -24 dBm; reply code is inconsequential. Reduce the spacing of the P1 - P3 pair in respect to the P1 - P2 pairs and determine suppression duration S(8) as in Step 4.</p> <p>Repeat the test using Mode C spacing for the P1 - P3 pair and determine suppression duration S(21).</p> | <p><u>Keep the 10% in ED 73C</u></p> <p>RHS Commentary:</p> <p>In this procedure, you are doing the same thing as in the last with the exception that you are providing two separate P1-P2 interrogation pairs. You are verifying that the suppression duration is now based on the second P1_P2 pair as opposed to the first.</p> <p>Therefore, you still want to move the P1-P3 interrogation into the second P1-P2 interrogation until there are NO REPLIES. So, you DO NOT want ED-73C to say 10%. ED-73C should be changed to read “at which the transponder ceases to reply”.</p> |
| <p>c. <u>STEP 3 - Recovery After Suppression</u> (Paragraph Error! Reference source not found. d.)</p> <p>Repeat <u>STEP 1</u> using the following signal levels:</p> <p>(1) P1-P2 pair = -30 dBm;</p> <p>(2) P1-P3 pair = MTL.</p> <p>Record the reply ratio observed when the P2 (suppression) P1 (interrogation) spacing is no more than 1 μs greater than S(8, 21) determined in previous steps.</p> <p>[Under environmental conditions, this procedure step is not required.]</p> | <p><u>Step 7 Recovery After Suppression [§2.2.5.1.d (4)]</u></p> <p>Repeat Step 5 using the following signal levels: P1 - P2 pair: -30 dBm; P1 - P3 pair: MTL.</p> <p>A reply efficiency of 90 percent should be observed when the P2 (suppression) P1 (interrogation) spacing is no more than one microsecond greater than S(8, 21) determined in previous steps.</p> | <p><u>Do we need to specify that reply efficiency should be 10 % in ED 73C ????</u></p> <p>RHS Commentary:</p> <p>In this procedure, you are verifying that the transponder has recovered from suppression within 1 microsecond after the suppression duration or period has ended. (See ICAO Volume IV, section 3.1.1.7.4.2.1 as given in the first RHS_Commentary in this document). Since you are attempting to verify full recovery, you want the reply rate to be 90% and NOT 10%. When not suppressed, the reply rate is set at 90% as per DO-181D section 2.2.5.1.b.</p> |
| <p>d. <u>STEP 4 - SLS Decoding</u> (Paragraph ED 73C 3.8.2 a.)</p> <p>Interrogate the transponder with a Mode A interrogation including a P2 pulse; (RF signal levels MTL+3dB, -50</p> | <p><u>Step 1 SLS Decoding [§2.2.5.1.a (1) and (3), §2.2.5.1.b and §2.2.8.5]</u></p> <p>Connect the equipment as shown in Figure 2-27. Interrogate the transponder with a standard Mode A interrogation including a P2 pulse. RF signal level to be</p> | <p>Note that Specification in both document (DO181 and ED 73) specifies a range from 1.85 to 2.15 μs</p> <p>(Why SC209 makes the test from 1 to 3 μs ?)</p> |

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| <p>dBm and -21 dBm; P2 level = P1 level).</p> <p>As the P1-P2 spacing is varied over the range from 1.85 to 2.15 μs, record the reply ratio and verify that it does not exceed 10%.</p> <p>[Under environmental conditions, it is sufficient to perform this test step with the RF signal level set to MTL+ 3 dB].</p> <p>h. <u>STEP 8 - Simultaneous Interrogation of Mode A/C with P2</u> (Simultaneous decoding of Mode A/C interrogation with Mode A/C suppression) (Paragraph ED 73C</p> <p>3.8.2 d.)</p> <p>Interrogate the transponder with a Mode A pulse pair with:</p> <ol style="list-style-type: none"> (1) RF signal level = -50dBm, (2) P2 level = P1 level. <p>Generate a 0.8 μs pulse, at the same level as P2, 8 μs before the leading edge of P2.</p> <p>Observe that the reply ratio is less than 10%.</p> <p>Repeat this test with the 0.8 μs pulse, 21 μs before the leading edge of P2.</p> <p>[Under environmental conditions, this procedure step is not required.]</p> | <p>at MTL +3 dB; P2 level = P1 level.</p> <p>As the P1 - P2 spacing is varied over 1.0 to 3.0 microseconds, determine the reply efficiency.</p> <p>Adjust the P1 - P2 spacing to the nominal value and insert a 0.8 microsecond pulse (equal in amplitude to P1 and P2) such that it occurs 8 microseconds before P2.</p> <p>Repeat with a 21-microsecond spacing between the inserted pulse and P2. Verify that the reply ratio is less than 1 percent.</p> <p><u>Step 2 SLS Dynamic Range [§2.2.5.1.a (2) and §2.2.5.1.c]</u></p> <p>Repeat Step 1 at RF signal levels: -60 dBm, -40 dBm and -21 dBm.</p> | <p><u>=> Change ED 73 to replace 10% by 1%.</u></p> <p><u>RHS Commentary:</u></p> <p>In this case, you are varying P1-P2 spacing over a range that covers the Must Accept range of 1.85 to 2.15 microseconds. That means that you have to accept the P1-P2 pair and therefore suppress which means no more than 1 percent reply. If no pulse (e.g., P2) is received at the position 2.0 +/- 0.7 microseconds following P1, the P1-P2 pair is rejected and the reply rate must be at least 90 percent. (See DO-181D section 2.2.5.1.b. and ED-73C paragraph 3.8.2.b). So, the 3 seconds comes from the minimum pulse width of 0.3 microseconds plus the time of 2.7 microseconds. The 1 second comes from 2.0 -0.7-0.3(minimum pulse width) = 1.0.</p> <p>In short, for the ED-73C test, P1-P2 must be detected and the reply rate should be less than 1 percent. Therefore, ED-73C should change from 10 percent to 1 percent.</p> <p><u>RHS Commentary:</u></p> <p>In this case, the transponder must detect a simultaneous P1-P2 suppression pair and a valid P1-P3 Mode-A interrogation. It must therefore SUPPRESS and the reply ratio must be less than 1 percent.</p> <p><u>=> Change ED 73 to replace 10% by 1%.</u></p> <p><u>RHS Commentary:</u></p> <p>In this case, the transponder must suppress and the reply rate must be less than one percent. Therefore, ED-73C should change 10 percent to one percent.</p> |
| <p>e. <u>STEP 5 - Short Duration P2</u> (Paragraph ED 73C</p> <p>3.8.2 b (3))</p> <p>Interrogate the transponder with a Mode A interrogation with :</p> <ol style="list-style-type: none"> (1) P2 level = P1 level, (2) P2 duration less than 0.3 μs. <p>Record the reply ratio and verify the minimum is at least 90% at signal levels of MTL+3dB, -50 and -21dBm.</p> | <p><u>Step 9 Short Duration P2 (§2.2.5.1.b.(3))</u></p> <p>Interrogate the transponder with a Mode A interrogation with</p> <ol style="list-style-type: none"> (1) P2 level = P1 level (2) P2 duration less than 0.3 μs <p>Record the reply ratio and verify the minimum is at least 90% at signal levels of MTL +3dB, -50 and -21 dBm.</p> | <p>OK</p> |

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| <p>[Under environmental conditions, this procedure step is not required.]</p> | | |
| <p>f. <u>STEP 6 - SLS Pulse Ratio</u> (Paragraph ED 73C) 3.8.2 b (1)) Interrogate the transponder with a Mode A interrogation including a P2 pulse; (P2 level = P1 -9dB). As the P1-P2 spacing is varied over 1 to 3 μs, record the reply efficiency and verify that the minimum is at least 90% at signal levels of MTL+3dB, -50 and -21dBm.</p> | <p><u>Step 3 SLS Pulse Ratio (§2.2.5.1.b)</u> Repeat Step 1 at RF signal levels between MTL +3 dB, (-60 dBm, -40 dBm and -21 dBm). Set P2 level 9 dB below P1 level <u>Step 4 SLS Pulse Ratio (§2.2.5.1 a and b)</u> Repeat Steps 1, 2 and 3 with an ATCRBS Mode A/Mode S All-Call interrogation (retaining the 8-microsecond spacing between P1 and P3, and add P4).</p> | <p>RHS Commentary: In this case, the procedure is DO-181D section 2.3.2.4, Step 3. The P2 pulse is 9 dB below P1; therefore, a P1-P2 pulse should not be detected, there should be no suppression, and the reply rate should be at least 90 percent in accordance with DO-181D section 2.2.5.1.b. It is the responsibility of the testing activity to determine the reply rate requirement by reviewing the requirements of section 2.2.5.1.b. <u>Keep the 90%. In ED 73C</u> Is it clear in D0181 that even if step 1 is repeated. In accordance with requirements 2.2.5.1.b it is 10% expected and not 1% ?? RHS Commentary: ED-73C should be at 90%. The requirement for DO-181D is also 90% as discussed just above and in accordance with section 2.2.5.1.b. <u>Same comment for ED73 : 1 to 3μs</u> RHS Commentary: Rationale for 1 to 3 microseconds was previously given in RHS_Commentary in regards to SLS Decoding above.</p> |
| <p>g. <u>STEP 7 - Suppression on Mode A/C/S All-Call</u> Repeat STEP 4, STEP 5, and STEP 6, with Mode A/C/S All-Call. [Under environmental conditions, this procedure step is not required.]</p> | | |
| <p>i. <u>STEP 9 - Low Signal Level Characteristics</u> (Paragraph ED 73C) 3.8.2 c.) Interrogate the transponder with a Mode A interrogation, including a P2 pulse (P2 = P1 level). Vary the signal level from MTL to MTL +3dB. Verify that the reply ratio does not exceed 10%. [Under environmental conditions, this procedure step is not required.]</p> | <p><u>Step 8 Low Signal Level Characteristics (§2.2.5.1.c)</u> Interrogate the transponder with a Mode A interrogation, including a P2 pulse (P2 = P1 level). Vary the signal level from MTL to MTL +3 dB. Verify that the reply ratio does not exceed 10%.</p> | <p><u>OK</u> RHS Commentary: Note that the 10% applies since you are now at the very low signal levels of MTL to MTL+3. See DO-181D section 2.2.5.1.c.</p> |